



ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

 @NASAARSET

Remote Sensing of Land Indicators of Sustainable Development Goal (SDG) 15

Instructors: Amber McCullum and Cindy Schmidt

Session 1: June 20th, 2017

Course Structure

- Three sessions: Tuesday, June 20; Wednesday, June 21; Thursday, June 22
 - Each session will be given twice:
 - Session A: 1:00 – 2:00 p.m. EDT (UTC-4)
 - Session B: 10:00 – 11:00 p.m. EDT (UTC-4)
 - Please only sign up for and attend the same session each week
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
 - <http://arset.gsfc.nasa.gov/land/webinars/sdg15>
 - Q&A: Following each lecture and/or by email
 - cynthia.l.schmidt@nasa.gov, or
 - amberjean.mccullum@nasa.gov

Homework and Certificates

- Homework
 - Answers must be submitted via Google Form
- Certificate of Completion:
 - Attend all 3 webinars
 - Complete the homework assignment by the deadline (access from ARSET website)
 - **HW Deadline: July 6th**
 - You will receive certificates approx. two months after the completion of the course from: marines.martins@ssaihq.com

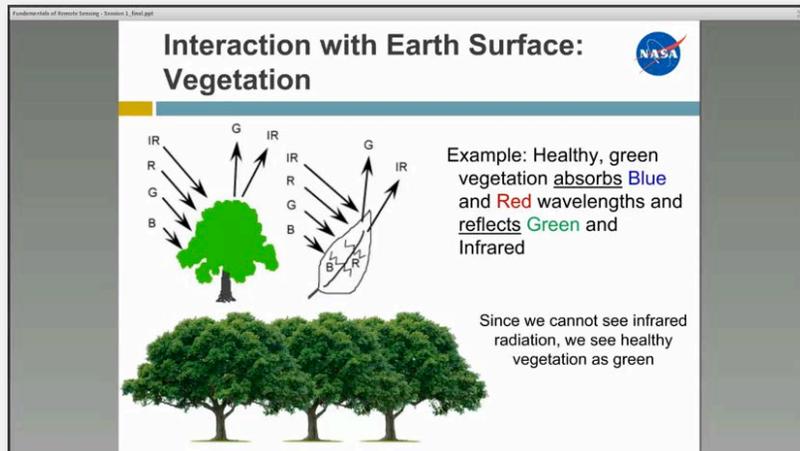
The image shows two overlapping documents. The top document is a Google Form titled "Carbon Monitoring Homework 1". It includes instructions to complete questions and submit by June 23rd, 2016. It has fields for "Name" and "Email", both marked as required. Below these are three multiple-choice questions:

1. Which of these data portals do NOT provide Landsat data? *
 - A. GloVis
 - B. Earth Explorer
 - C. MRTWeb
 - D. WELD
2. What is the formula for NDVI? *
 - A. $(\text{Red} - \text{Near Infrared}) / (\text{Blue} - \text{Near Infrared})$
 - B. $(\text{Near Infrared} - \text{Red}) / (\text{Near Infrared} + \text{Red})$
 - C. $(\text{Green} - \text{Blue}) / (\text{Green} + \text{Blue})$
 - D. $(\text{Red} - \text{Green}) / (\text{Near Infrared} - \text{Green})$
3. Chlorophyll in plants absorbs green waveler

The bottom document is a Certificate of Completion from ARSET (Applied Remote Sensing Training). It is presented by Land Management to Amber McCullum for completing advanced training on "Remote sensing of forest cover and change assessment for carbon monitoring". The certificate is dated June 9 - July 7, 2016. It features the NASA logo and the text "National Aeronautics and Space Administration".

Prerequisite

- Fundamentals of Remote Sensing
 - Sessions 1 and 2A (Land)
 - On demand webinar, available anytime
 - <http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>



NASA ARSET
Applied Remote Sensing Training

Earth Sciences Division Applied Sciences ASP Water Resources

Search this site

Home About Trainings

Applied Remote Sensing Fundamentals

Disasters
Health & Air Quality
Land
Water Resources

Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications

Thursdays, June 1-15, 2017
10 a.m. or 3 p.m. EDT (UTC-4)

Register Now

Image Credit: NASA Earth Observatory

ARSET

Webinars
Workshops
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Upcoming Training

Airquality

Satellite Remote Sensing of Air Quality: Data, Tools and Applications
05/23/2017 to 05/26/2017

Airquality

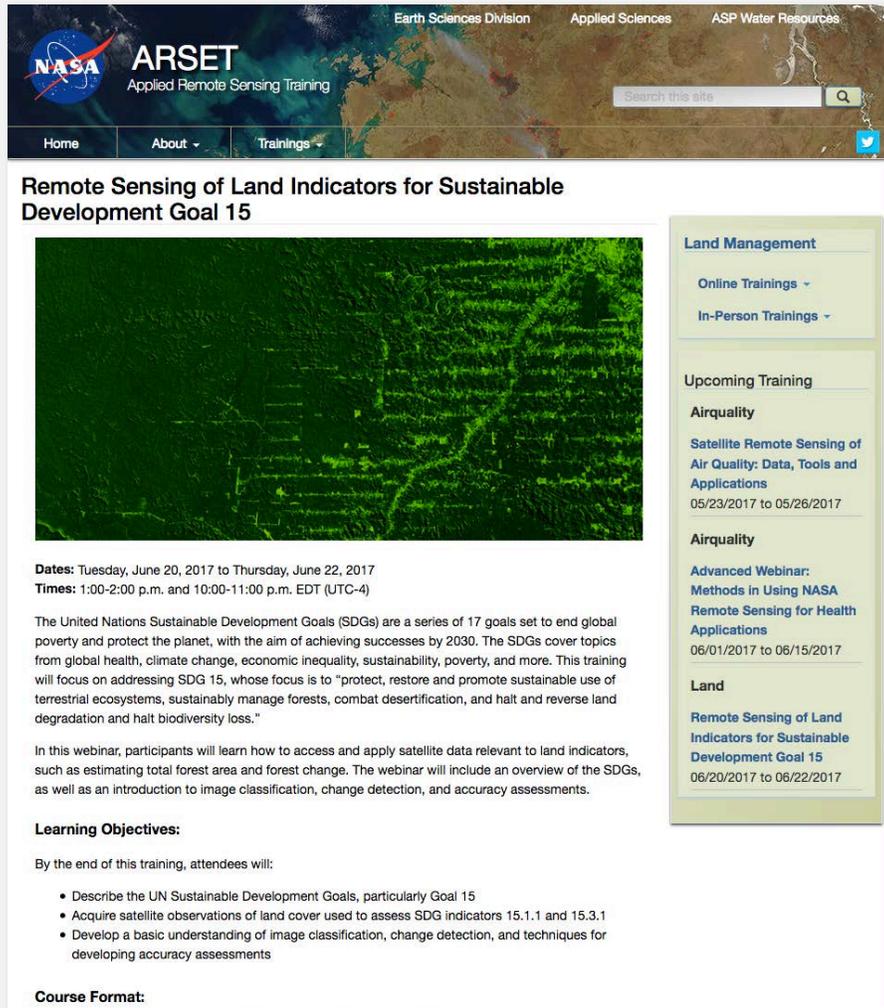
Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications
06/01/2017 to 06/15/2017

Land

Remote Sensing of Land

Accessing Course Materials

<http://arset.gsfc.nasa.gov/land/webinars/sdg15/>



The screenshot shows the ARSET website header with the NASA logo and navigation menu. The main content area features a satellite image of a forest. The page title is 'Remote Sensing of Land Indicators for Sustainable Development Goal 15'. Below the image, there are sections for 'Dates', 'Times', a description of the course, 'Learning Objectives', and 'Course Format'. A sidebar on the right contains navigation links for 'Land Management', 'Upcoming Training', and 'Land'.

Remote Sensing of Land Indicators for Sustainable Development Goal 15

Dates: Tuesday, June 20, 2017 to Thursday, June 22, 2017
Times: 1:00-2:00 p.m. and 10:00-11:00 p.m. EDT (UTC-4)

The United Nations Sustainable Development Goals (SDGs) are a series of 17 goals set to end global poverty and protect the planet, with the aim of achieving successes by 2030. The SDGs cover topics from global health, climate change, economic inequality, sustainability, poverty, and more. This training will focus on addressing SDG 15, whose focus is to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."

In this webinar, participants will learn how to access and apply satellite data relevant to land indicators, such as estimating total forest area and forest change. The webinar will include an overview of the SDGs, as well as an introduction to image classification, change detection, and accuracy assessments.

Learning Objectives:

By the end of this training, attendees will:

- Describe the UN Sustainable Development Goals, particularly Goal 15
- Acquire satellite observations of land cover used to assess SDG indicators 15.1.1 and 15.3.1
- Develop a basic understanding of image classification, change detection, and techniques for developing accuracy assessments

Course Format:

Audience:

Regional, state, federal, and international organizations interested in addressing monitoring requirements for the SDGs through the use of remote sensing. Professional organizations in the public and private sectors engaged in environmental management and monitoring will be given preference over organizations focused primarily on research.

Registration Information:

There is no cost for the webinar, but you must register. Space is limited, and preference will be given to organizations listed above over organizations focused primarily on research. You will be notified by email if your registration has been approved on or before June 16, 2017. Please register for **only one session**.

- [Register for Session A, 1:00 - 2:00 p.m. EDT \(UTC-4\)](#) »
- [Register for Session B, 10:00 - 11:00 p.m. EDT \(UTC-4\)](#) »

Course Agenda:

[Agenda.pdf](#)

Session One: Overview of SDG 15

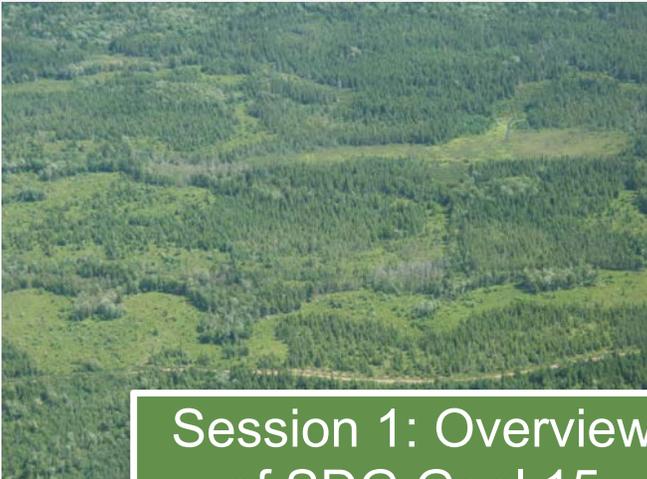
June 20, 2017

- [Presentation Slides \(English\)](#) »
- [Presentation Slides \(Spanish\)](#) »
- [View the recording](#) »

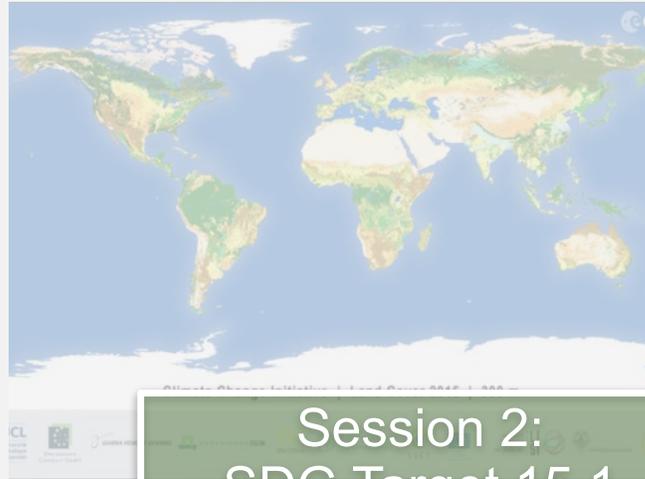
- Introduction to the Sustainable Goals Framework
 - Overview of SDG 15
 - International Institute for Sustainable Development's (IISD's) SDG Knowledge Hub
 - Group on Earth Observations (GEO) and the SDGs
- State of the World's Forests
- Introduction to the role of land-based remote sensing for targets and indicators
- Remote sensing data sources for assessment of land cover
 - Landsat
 - MODIS
 - VIIRS
 - Sentinel

Course materials are provided here and will be active after each week

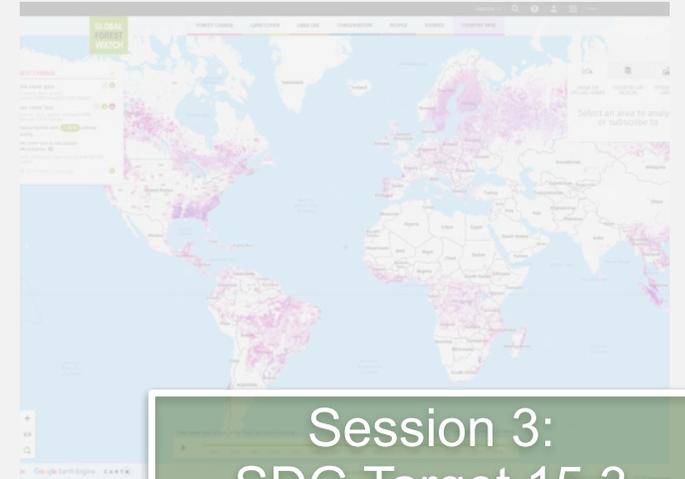
Course Outline



Session 1: Overview
of SDG Goal 15



Session 2:
SDG Target 15.1



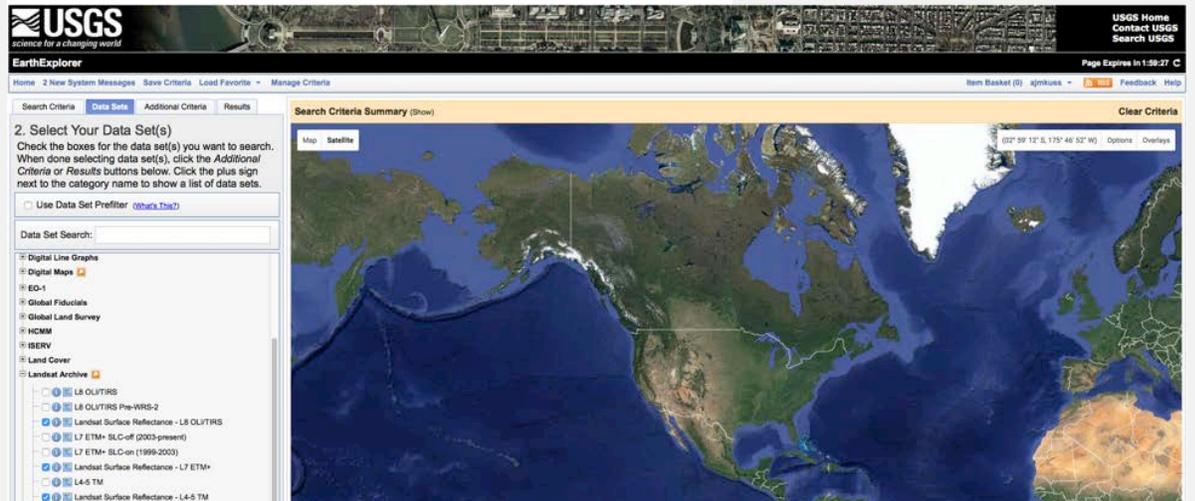
Session 3:
SDG Target 15.3

Session 1 Agenda

- About ARSET
- Introduction to the Sustainable Goals Framework
- Related Forest Conservation Efforts
- State of the World's Forests
- The Role of Remote Sensing for SDG 15
- Remote Sensing Data Sources for Land Cover



(Left)
Sustainable
Development
Goals Credit:
United Nations.
(Below) USGS
EarthExplorer



About ARSET

NASA's Applied Remote Sensing Training Program (ARSET)

<http://arset.gsfc.nasa.gov/>

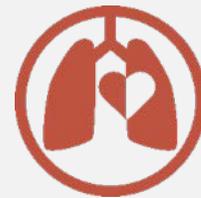
- Empowering the global community through remote sensing training
- Part of NASA's Applied Sciences Capacity Building Program
- Goal: increase the use of Earth Science in decision-making through training for:
 - policy makers
 - environmental managers
 - other professionals in the public and private sector
- Trainings offered focusing on applications in:



Disasters



Land



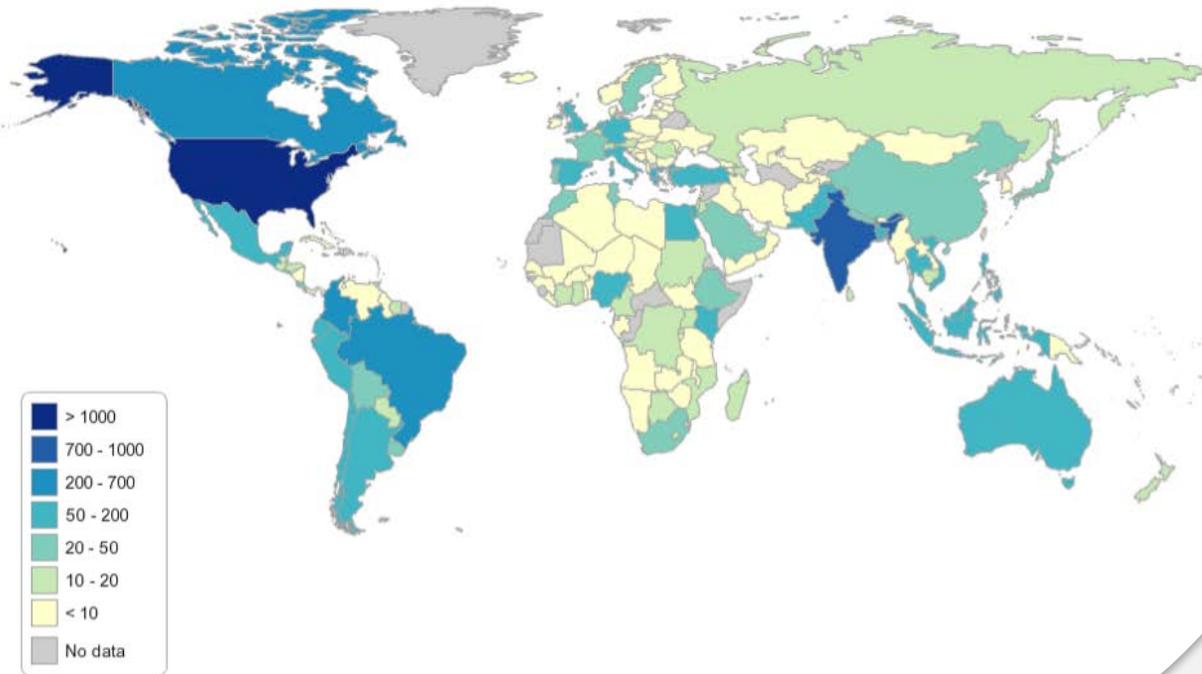
Health & Air Quality



Water Resources

ARSET's Global Footprint

**ARSET Participants by Country
2009 – 2016**



85 ARSET Trainings

9,000+ participants reached

2,600+ organizations reached

150+ countries reached

55 U.S. States, Territories, and D.C. reached

ARSET Training Levels

Fundamentals

- Online only
- Assumes no prior knowledge of remote sensing

Basic Training

- Online and in-person
- Requires fundamentals training or equivalent knowledge
- Specific applications

Advanced Training

- Online and in-person
- Requires basic training or equivalent knowledge
- More in-depth or focused topics



Fundamentals of Remote Sensing: Satellites, Sensors, Data, and Tools for Land Management & Wildfire Applications

Basic Training: Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring

Advanced Training: Advanced Webinar: Land Cover Classification with Satellite Data

ARSET Website: View Webinars

<http://arset.gsfc.nasa.gov/webinars>

ARSET-Dev
Applied Remote Sensing Training

Home About Trainings

Applied Remote Sensing Training

Using NASA Remote Sensing for Disaster Management
June 9-30, 2016
Thursdays
11:00 a.m. - 12:00 p.m. and 6:00-7:00 p.m. EDT
[Learn More](#)

ARSET

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- Workshops
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- Personnel
- Resources

Upcoming Training

Disasters

Using NASA Remote Sensing for Disaster Management
06/09/2016 to 06/30/2016

Airquality

Fundamentals of Satellite Remote Sensing for Health Monitoring
06/02/2016 to 06/30/2016

Land

Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring
06/09/2016 to 07/07/2016

ARSET helps professionals build the necessary skills to integrate NASA Earth Science data into their agency's decision-making activities. Trainings are offered in areas of disasters, health & air quality, land, water resources, and wildfires.

By hosting online webinars and in-person workshops, ARSET has had over 4,000 participants from more than 130 countries how to access, visualize, and apply NASA remote sensing data and imagery.

Trainings teach professionals how to:

- search, access, and use NASA data products
- use and interpret satellite imagery appropriately
- visualize and analyze NASA data and imagery using NASA, EPA, and NOAA web-based tools; GIS; Google Earth; Panoply; HDFLook; and other resources.

If you or your organization is interested in suggesting a training topic or hosting a training, [let us know](#).

ARSET is sponsored by the Applied Sciences Program within NASA's Earth Sciences Division. We would like to thank Nancy Searby, Applied Science' Capacity Building Program Manager, for her support of this project.

Stay Informed

If you would like information on upcoming workshops and project activities please sign up for the listserv.

Last updated: May, 06, 2016
NASA Official: Kenneth Pickering
Webmaster: Susannah Pearce

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- Sciences and Exploration
- Atmospheric Chemistry & Dynamics

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Applied Remote Sensing Training

Home About Trainings

Webinars

ARSET offers online webinars throughout the year. Each training lasts four to five weeks, one hour per week, and are often offered twice a day to accommodate attendees in different time zones. Webinars are appropriate for professionals engaged in applied environmental management.

These online courses help beginners and advanced professionals use NASA Earth science data and modeling in areas of air quality, disaster management, land management, water resources, and wildfire detection and modeling.

ARSET hosts both introductory and advanced webinars. Check the individual webinar page for its level and more information. Most webinars have materials available in English and Spanish.

Introductory Webinars

Trainings are appropriate for applied professionals with no remote sensing experience.

Advanced Webinars

Trainings are appropriate for professionals with experience in remote sensing or NASA data and resources. Advanced topics will detail specific data or applications by region or discipline. These advanced trainings have case studies and hands-on exercises for participants on data access and processing.

Introduction to Satellite Remote Sensing for Air Quality Applications

Wednesday, July 6, 2016 to Wednesday, August 3, 2016
8:00 - 9:00 a.m. EDT (UTC-4)
Application Area: [Airquality](#)
Instruments/Missions: Aqua, Aura, CALIPSO, MISR, MODIS, NPP, Terra
Keywords: Aerosols, Air Pollution, Pollution Transport, Satellite Imagery, Tools, Trace Gases
[Read more](#)

Introduction to Remote Sensing for Coastal and Ocean Applications

Wednesday, July 6, 2016 to Wednesday, July 27, 2016
1:00-2:00 p.m. EDT (UTC-4)
Application Area: [Land](#), [Water](#)
Instruments/Missions: Aqua, MODIS, NPP, Terra, VIIRS
Keywords: Satellite Imagery, Tools, Water Quality
[Read more](#)

Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring

Thursday, June 9, 2016 to Thursday, July 7, 2016

ARSET

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- [Resources](#)

Upcoming Training

Disasters

Using NASA Remote Sensing for Disaster Management
06/09/2016 to 06/30/2016

Airquality

Fundamentals of Satellite Remote Sensing for Health Monitoring
06/02/2016 to 06/30/2016

Land

Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring
06/09/2016 to 07/07/2016

Last updated: May, 06, 2016
NASA Official: Kenneth Pickering
Webmaster: Susannah Pearce

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Overview of SDGs

UN Sustainable Development Goals (SDGs)

Transforming Our World: The 2030 Agenda for Sustainable Development

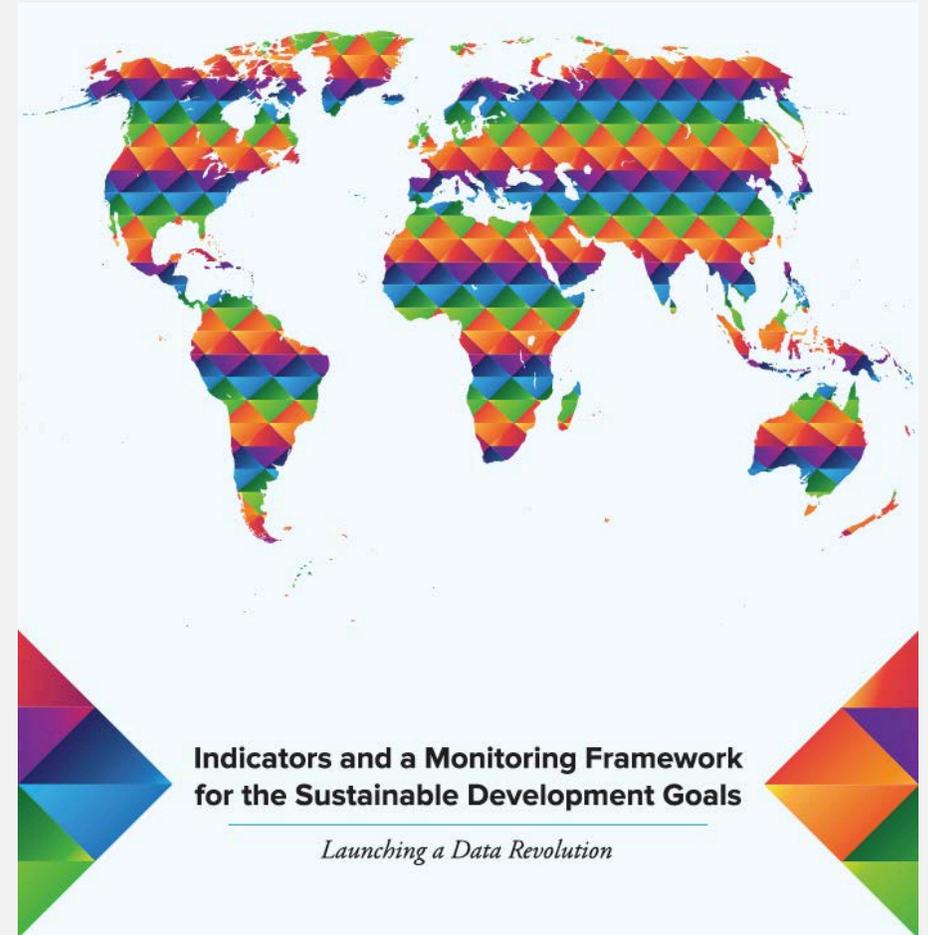
- A plan of action for people, planet and prosperity
- All countries and all stakeholders, acting in collaborative partnership, will implement this plan
- 17 SDGs and 169 targets under this agenda
- Balance the three dimensions of sustainable development:
 - economic, social, and environmental
- In this webinar series, our focus will be Goal 15: Life on Land



Text adapted from "[Transforming our world: the 2030 Agenda for Sustainable Development](#)"

SDG Indicators

- Used to monitor progress towards SDGs at local, regional, and global levels
- Turns SDGs and targets into a management tool:
 - develop implementation strategies
 - measure progress (report card)
- 100 Global Monitoring Indicators
 - includes suggestions for complementary national indicators (CNIs)
- Each country chooses the number and range of CNIs to collect and analyze data



<http://unsdsn.org/resources/publications/indicators/>

SDG: Target 15.1

- By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
 - Indicator: 15.1.1: Forest area as a proportion of total land area



SDG: Target 15.3

- By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
 - Indicator: 15.3.1: Proportion of land that is degraded over total land area
 - Subindicators: Land Cover and Land Cover Change, Land Productivity, Carbon Stocks



Agency Coordination



 Statistics Division

 **United Nations**
Convention to Combat
Desertification

 **SUSTAINABLE DEVELOPMENT
SOLUTIONS NETWORK**
A GLOBAL INITIATIVE FOR THE UNITED NATIONS



 **IISD**
International Institute for
Sustainable Development

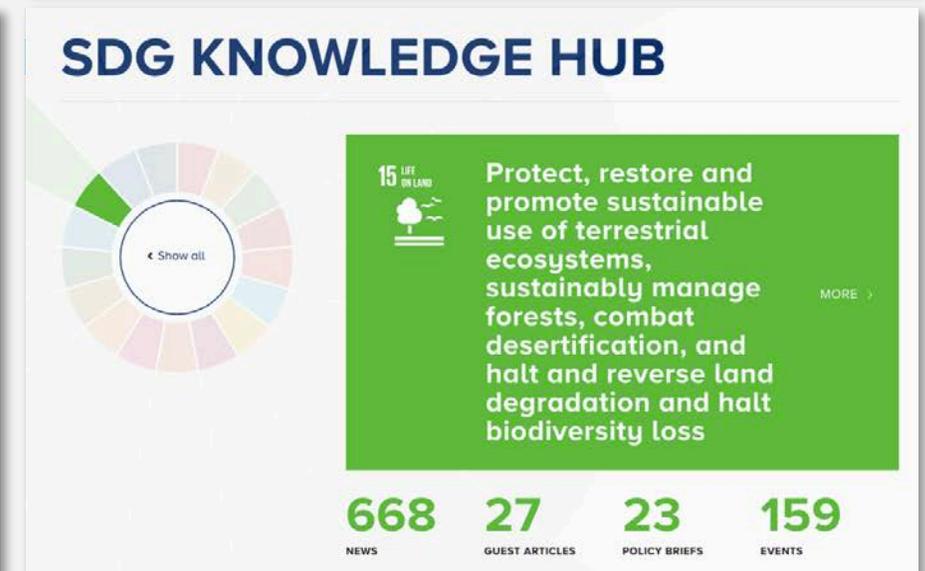
 **Food and Agriculture Organization
of the United Nations**

 **GROUP ON
EARTH OBSERVATIONS**

IISD Knowledge Hub

<http://sdg.iisd.org/>

- Provides tools and resources about the SDGs
- Collects news, events, policy briefs for specific goals
- Also provides information on events, actors, and regions



United Nations: Statistics for SDGs

<https://unstats.un.org/sdgs/indicators/database/>

- Access SDG data for specific countries
- Obtain metadata and methodology for calculating indicators
- Groups information based on regions

United Nations » Department of Economic and Social Affairs » Statistics Division

SUSTAINABLE DEVELOPMENT GOALS

HOME NEWS HLG-PCCB IAEG-SDGs EVENTS **SDG INDICATORS** REPORTS

SDG Indicators Global Database

Welcome to the dissemination platform of the [Global SDG Indicators Database](#). This platform provides access to data compiled through the UN System in preparation for the Secretary-General's annual report on "Progress towards the Sustainable Development Goals".

The data series identified by the symbol **SD** correspond to the global indicator framework that was agreed, as a starting point, by the [Statistical Commission at its forty-seventh session](#) in March 2016. Additional series are identified by the symbol **+**.

The development of this global SDG database dissemination platform is an ongoing process led by the United Nations Statistics Division, and it will continue to be further improved over time. Please send your comments to [sdgindicators@unstats.un.org](#).

Indicator : 15.1.1 - Forest area as a proportion of total land area

Available series:

SD Forest area as a proportion of total land area

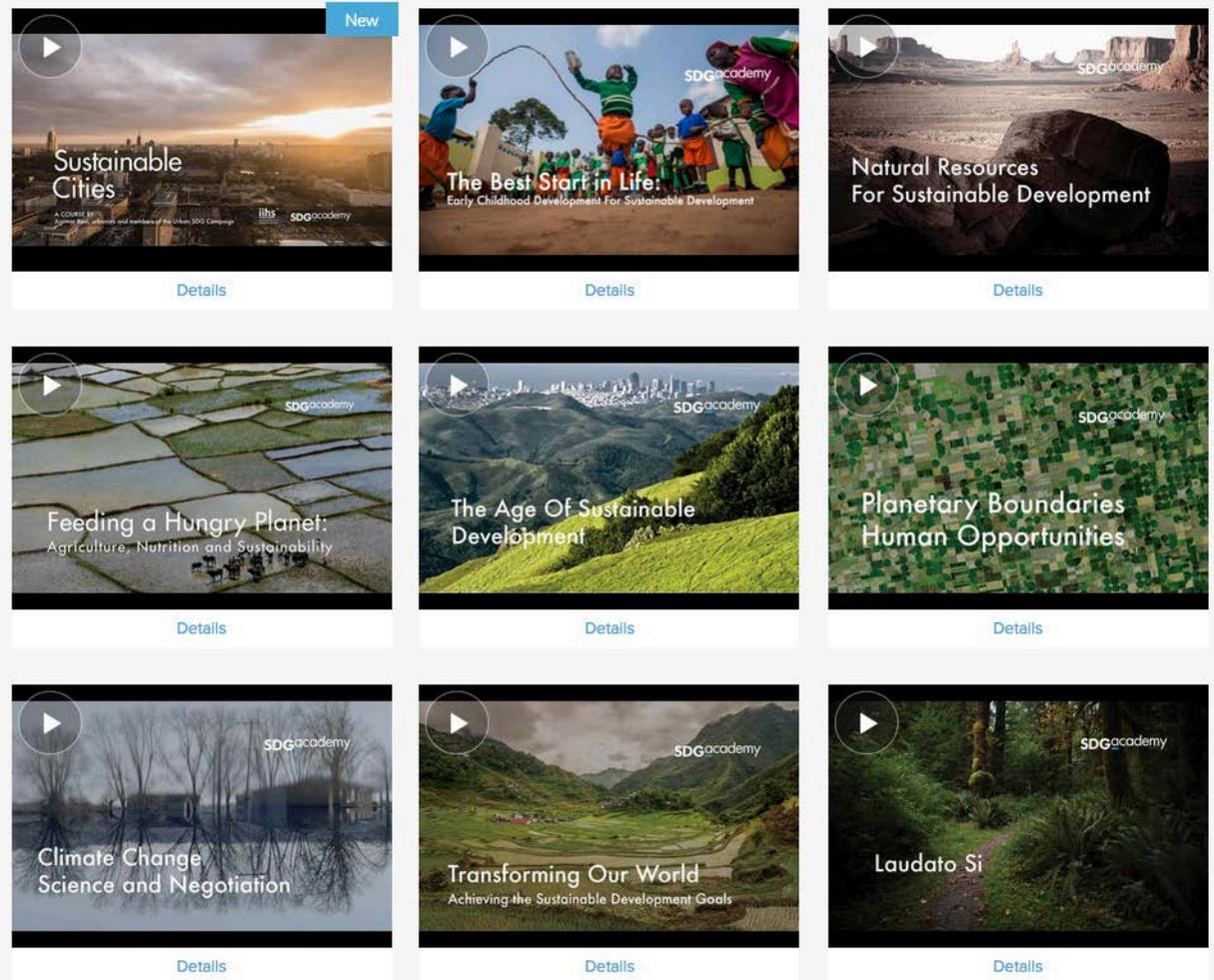
CSV Excel Search:

Series Description	Country or Area	Frequency	Unit	Location	Age Group	Sex
SD Forest area as a proportion of total land area	Channel Islands	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Aruba	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Afghanistan	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Angola	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Anguilla	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Albania	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Andorra	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	United Arab Emirates	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Argentina	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Armenia	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	American Samoa	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Antigua and Barbuda	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Australia	Annual	Percent (Units)	Total	Total	
SD Forest area as a proportion of total land area	Austria	Annual	Percent (Units)	Total	Total	

Sustainable Development Solutions Network (SDSN)

<http://courses.sdgacademy.org/>

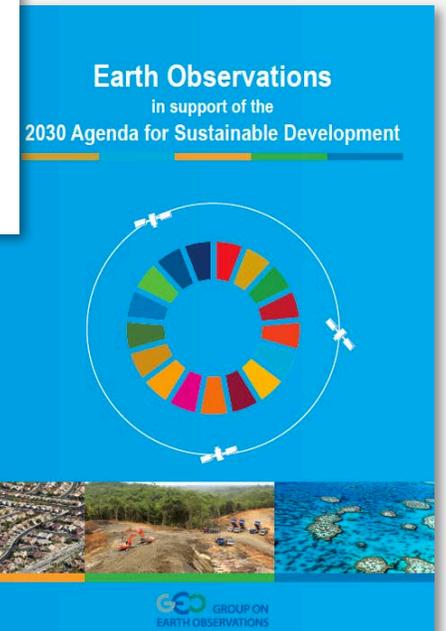
- Analytical and technical recommendations for SDGs
- SDG Academy
 - Free online courses about SDGs



Group on Earth Observations (GEO)

http://www.earthobservations.org/geo_sdgs.php

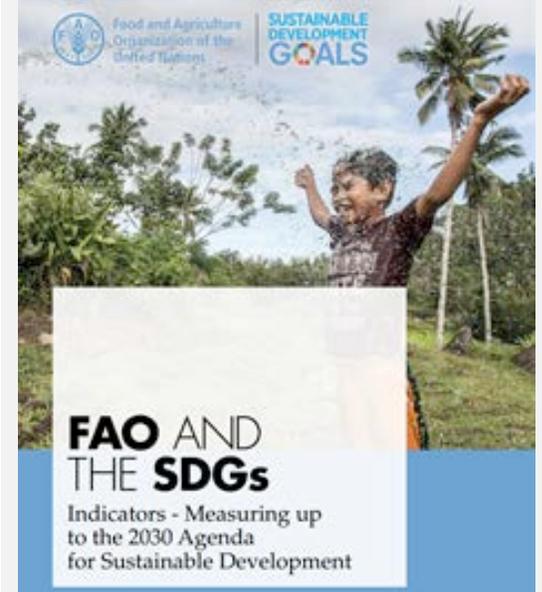
Initiative to support efforts to integrate Earth observations and geospatial information into national development and monitoring frameworks for the SDGs



Food and Agriculture Organization (FAO)

<http://www.fao.org/sustainable-development-goals/en/>

- FAO's priorities for the SDGs are:
 - End poverty, hunger and malnutrition
 - Enable sustainable development in agriculture, fisheries and forestry
 - Combat and adapt to climate change



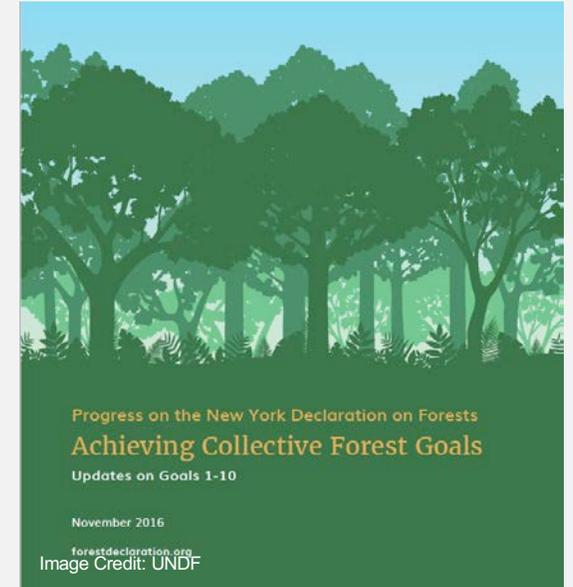


Related Forest Conservation Efforts

The New York Declaration on Forests

<http://forestdeclaration.org/>

- Many world leaders endorsed a timeline to cut natural forest loss in half by 2020 and to strive to end it by 2030
- Ten main goals
- Concrete actions and plans
 - Includes
 - commodity traders
 - indigenous peoples
 - commitments from country governments
 - multilateral programs
 - new procurement policies for use of forests



The Bonn Challenge

<http://www.bonnchallenge.org/>

- Global effort to restore 150 million hectares of the world's deforested and degraded land by 2020 and 350 million hectares by 2030
- Uses the Forest Landscape Restoration Approach (FLR)
- Vehicle for assisting in implementation of existing international commitments like REDD+

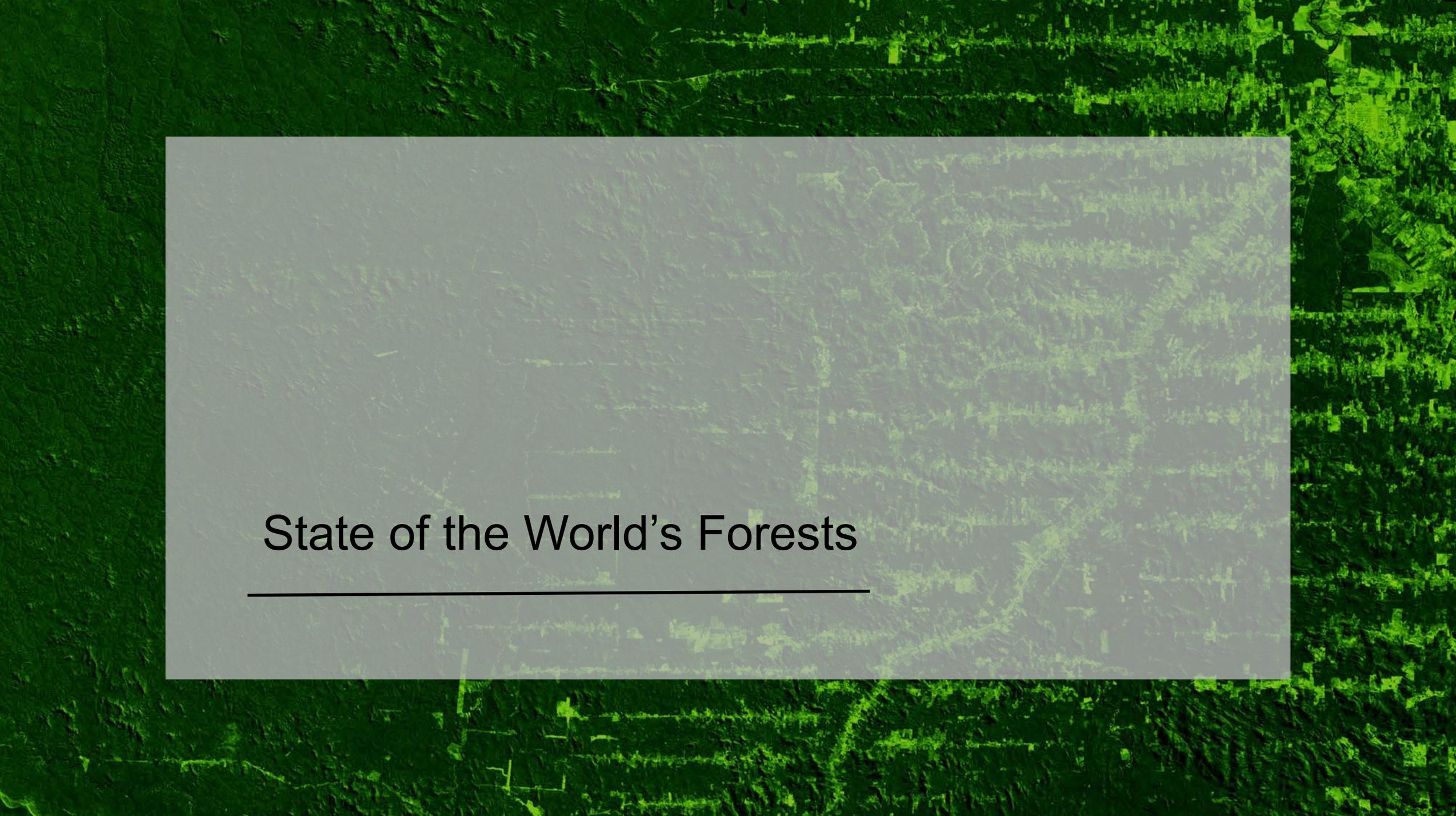


The United Nations REDD Program

<http://www.un-redd.org/>

- Reducing Emissions from Deforestation and Forest Degradation (REDD+)
- Climate change mitigation solution
- Incentivizes developing countries to keep forests by offering results-based payments for actions to reduce or remove forest carbon emissions
- Includes:
 - Reducing emissions from deforestation
 - Reducing emissions from forest degradation
 - Conservation of forest carbon stocks
 - Sustainable management of forests
 - Enhancement of forest carbon stocks

} REDD
+

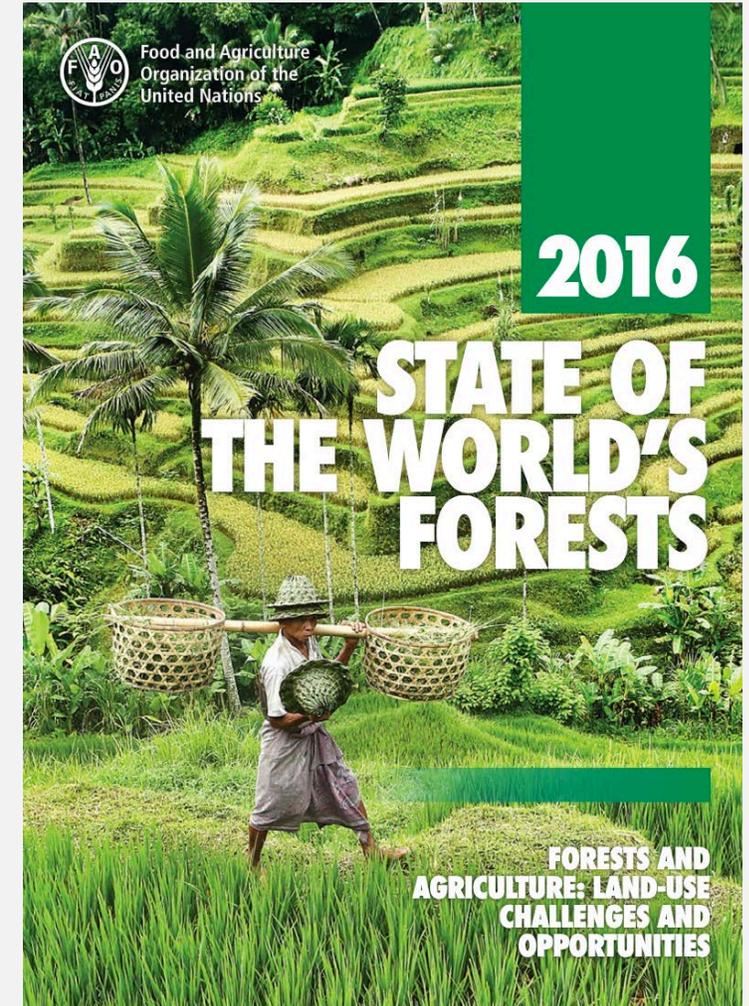
An aerial photograph of a dense, lush green forest. The trees are packed closely together, creating a textured, vibrant green surface. A semi-transparent white rectangular box is overlaid on the center of the image, containing the title text. The text is in a clean, black, sans-serif font. Below the text, a thin black horizontal line extends across the width of the text.

State of the World's Forests

FAO 2016 Report

<http://www.fao.org/publications/sofo/2016/en/>

- Explores the relationship between forests, agriculture, and sustainable development
- Agriculture: major driver of deforestation globally
- Case studies of countries that have reconciled increased agricultural productivity and halting deforestation
- Focus on integrated land use planning

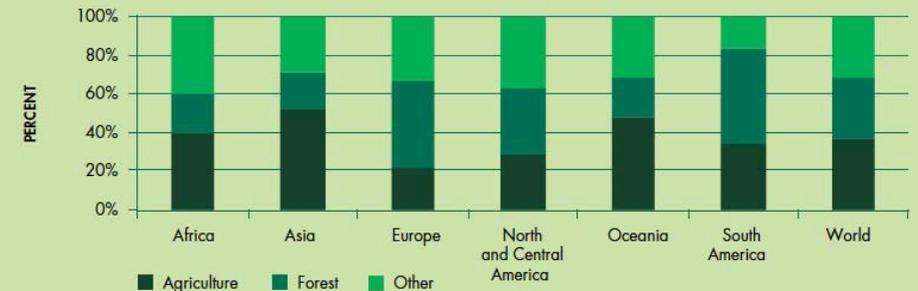


Trends in Land Use Change

- Forests account for large portion of total land area in Europe, North America, Central America, and South America
- Global forest area fell by 3.1% from 1990-2015
- Net forest loss of 7 million hectares per year in tropical countries in 2000-2010

FIGURE 2.1

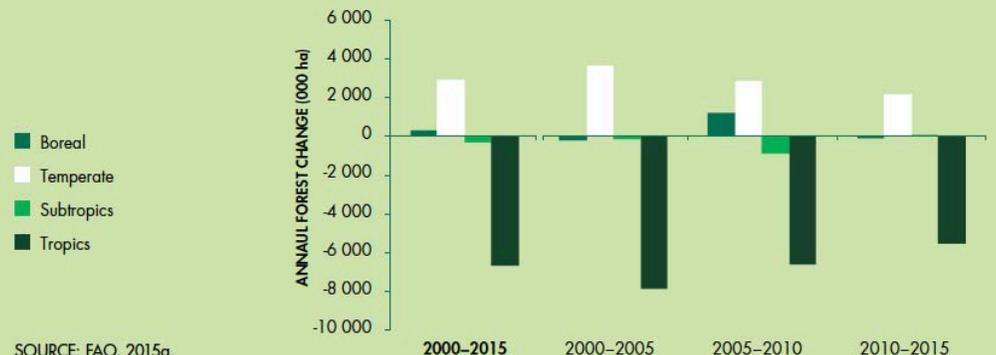
LAND AREA BY MAJOR LAND-USE CLASS, 2010



Note: "Other land" is all land not categorized as agricultural or forest land.
SOURCE: FAO, 2015a, 2016a.

FIGURE 2.3

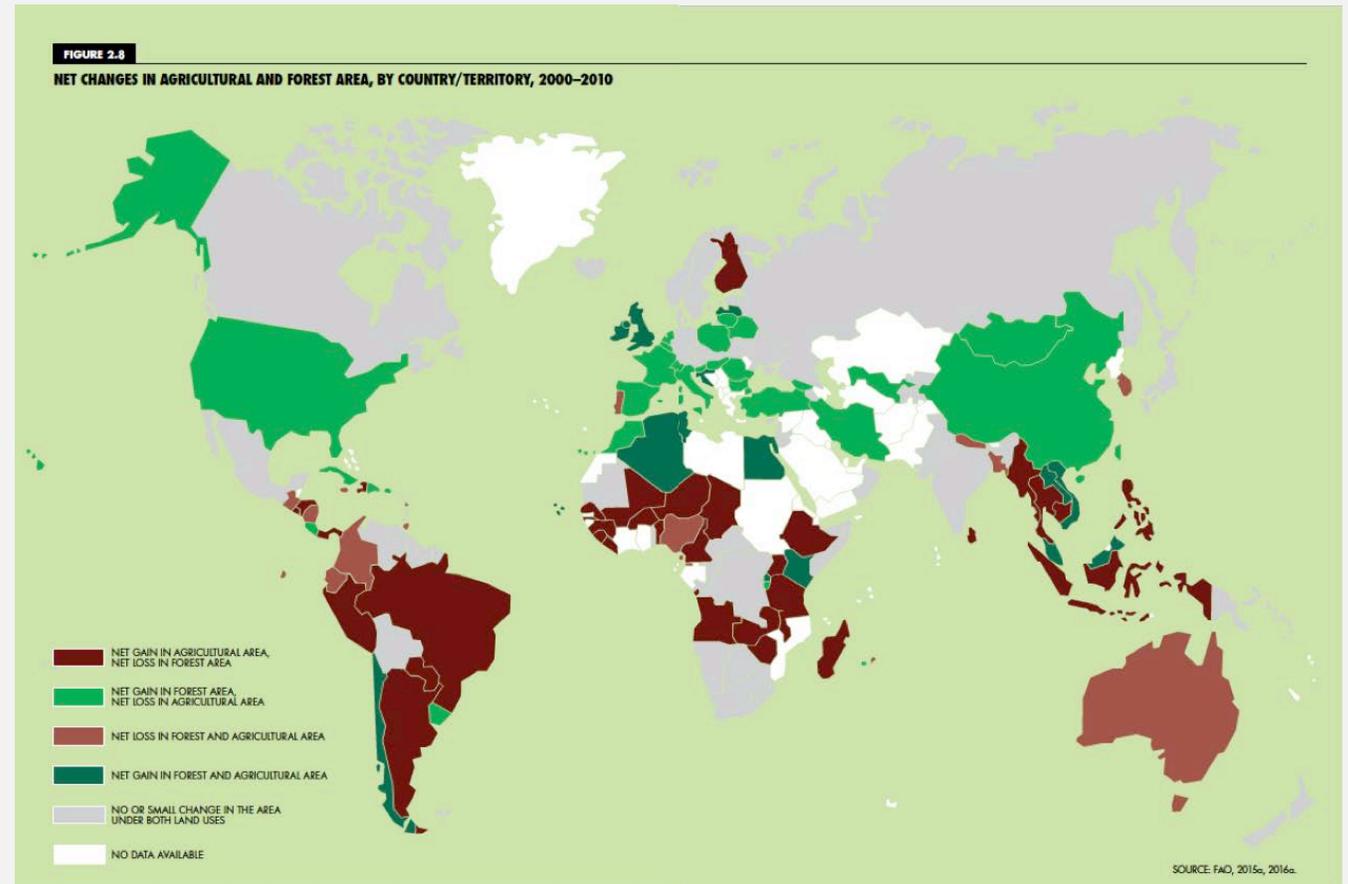
NET ANNUAL AVERAGE FOREST AREA CHANGE, BY CLIMATIC DOMAIN (000 ha per year)



SOURCE: FAO, 2015a.

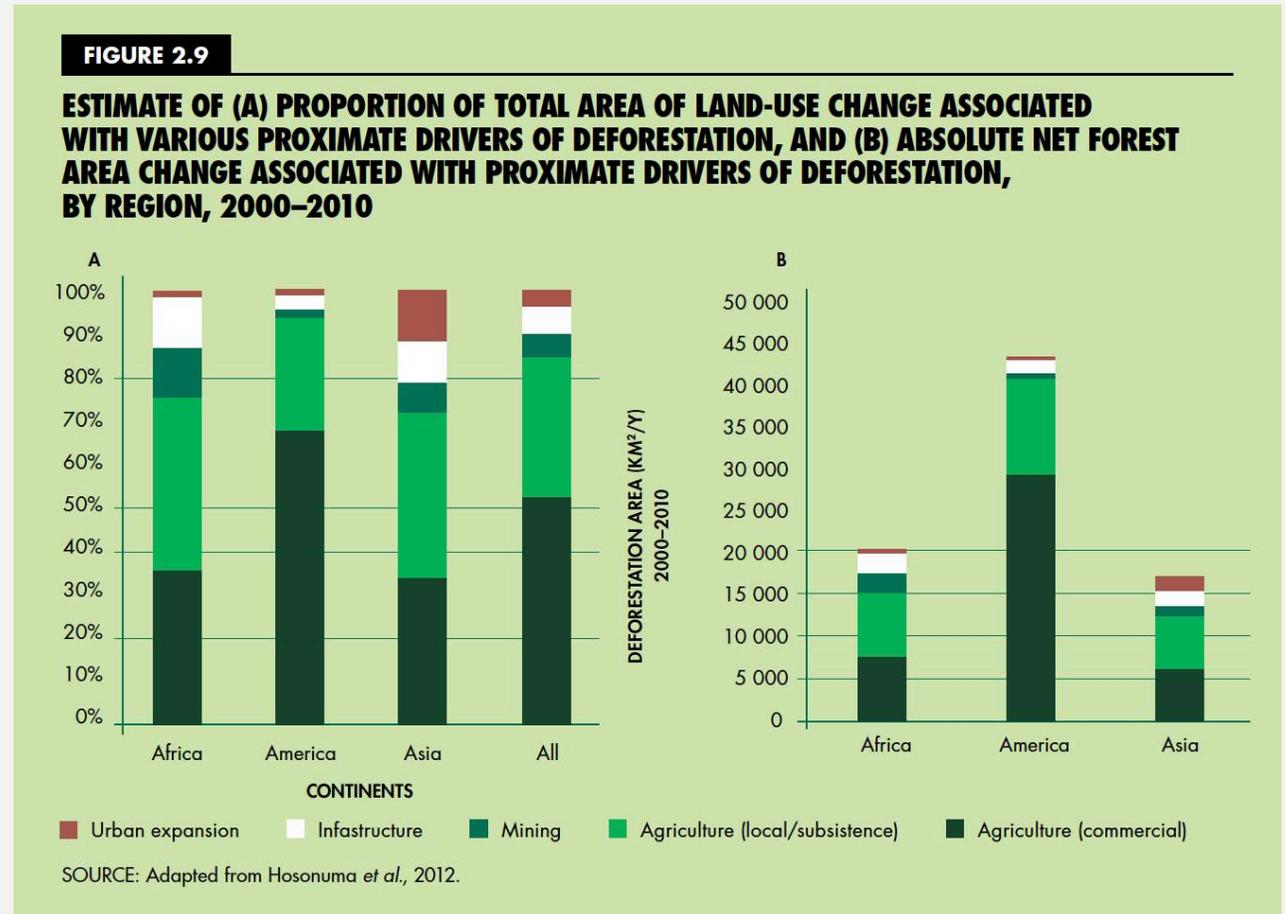
Trends in Land Use Change

- Strong correlation between agricultural expansion and deforestation in South America, sub-Saharan Africa, and South and Southeast Asia.
- Largest annual net loss of forest area occurred in low-income countries



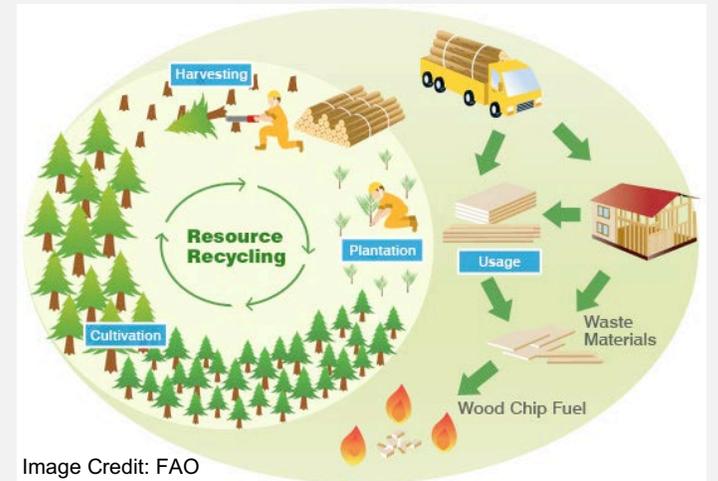
Drivers of Land Use Change

- Commercial and subsistence agriculture accounts for 73% of deforestation in tropics and subtropics
- Other factors affecting forest conversion:
 - Population
 - Changing food consumption patterns
 - Technological advancements
 - Policy interventions



Management of Land Use Change

- International policies and frameworks to address deforestation
 - SDGs
 - Paris Agreement on Climate Change
- Legal frameworks for managing land use change are usually complex and vary among countries
- Difficult to ensure legal compliance
- Land use planning, investments, adequate monitoring of land use change, and coordinated efforts are key in addressing forest loss



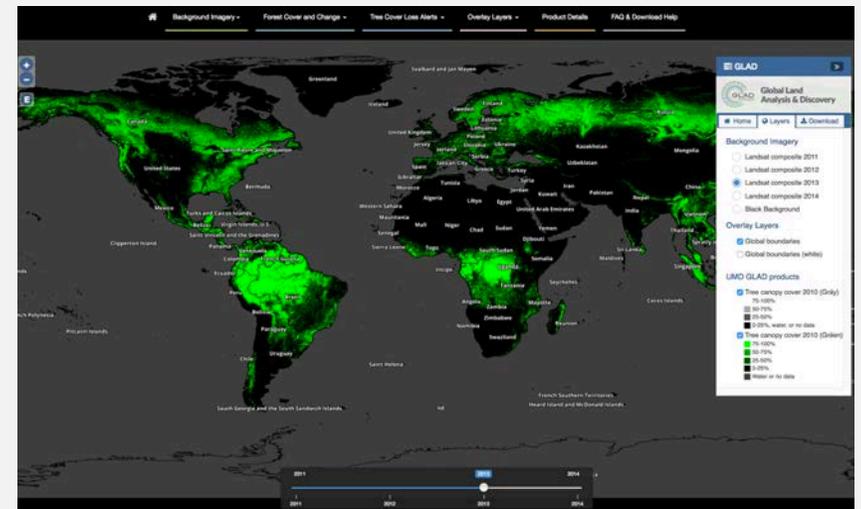
Remote Sensing for SDGs

Multi-data Framework

- SDGs recognize need for reporting based on multiple data types
 - “...to exploit the contribution to be made by a wide range of data, including Earth Observation and geospatial information, while ensuring national ownership in supporting and tracking progress.”
- Earth observation data are often continuous in their spatial and temporal resolutions
 - Essential in capturing changes and progress related to SDGs over time

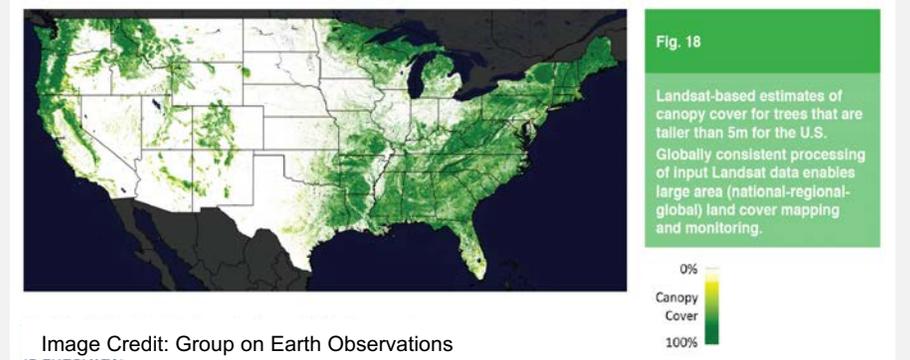
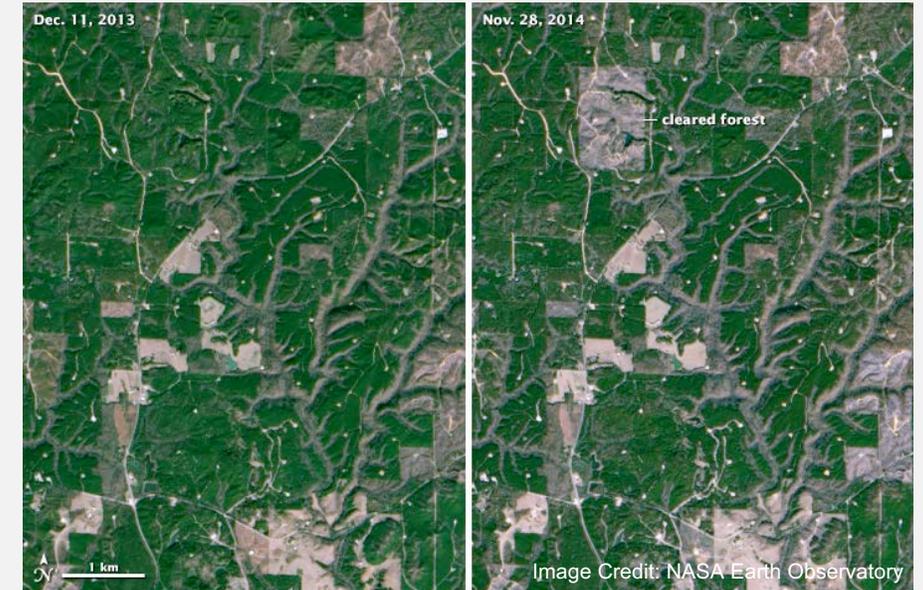


Image Credit: National Park Service (left), Global Land Analysis and Discovery (bottom)



Characteristics of Earth Observations

- Available for large regions
 - Only source of global information for some parameters
- Long time series and data continuity
 - Track progress
 - Establish baseline and trends
- Consistency and comparability
 - Among multiple countries
- Diversity of measurements
 - Many different physical parameters
- Complementarity with traditional statistical methods
 - Cross-check with in-situ data
- Mostly free and open access



Remote Sensing Data Sources

Considerations

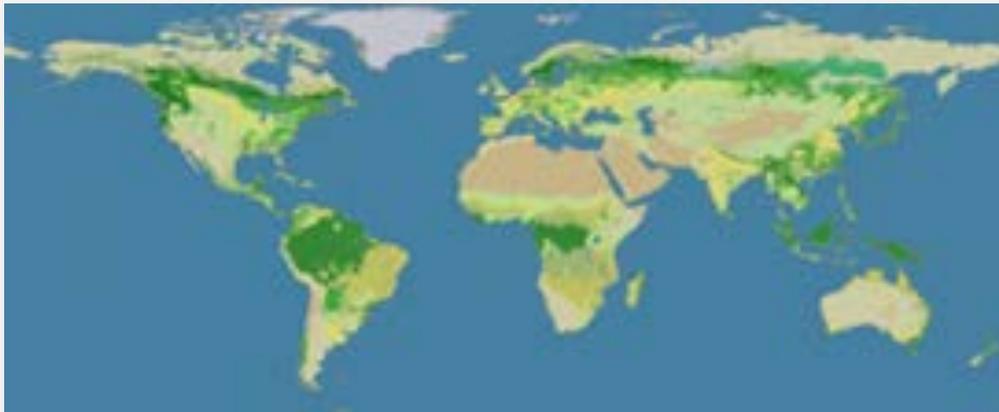
- What **geographical, phenological, and atmospheric** (especially persistent cloud cover) conditions exist?
- What is the **spatial resolution** of the data and how appropriate is it, relative to the scale of the land-cover changes to monitor?
- What is the **temporal resolution** in terms of potential frequency of acquisition of non-cloudy observations compared to the desired frequency of monitoring?
- What are the **spectral regions**, and bands within them, and how do these relate to the potential for distinguishing the land-cover types of interest, and changes among them?
- What is the **longevity of the image archive length** – does this meet the historical mapping needs?
- What are the **cost implications** of these data in terms of purchase and analysis?
- What are the **future satellite development** and launch commitments?

Remote Sensing Data Sources

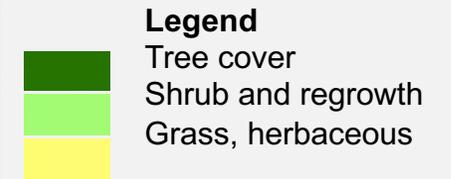
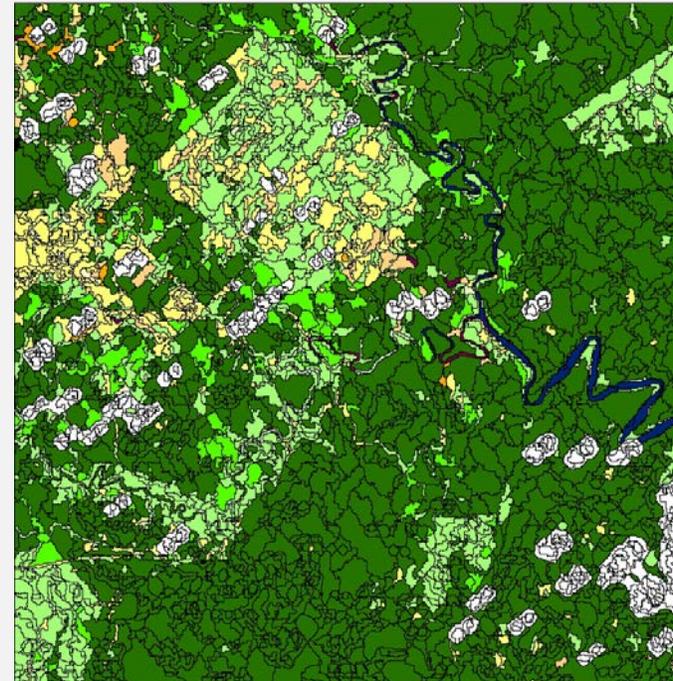
Overview

- Coarse spatial resolution (optical)
- Medium spatial resolution (optical)
- High spatial resolution (optical)
- Synthetic Aperture Radar
- LiDAR

MODIS Land Cover Map



Landsat Land Cover Map

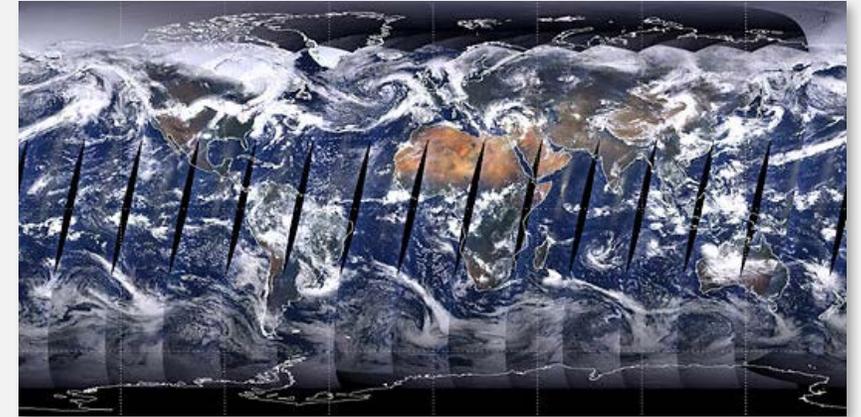


Sources: USGS 2015, GLS dataset; Bodart et al. 2011; and Raši et al. 2011.

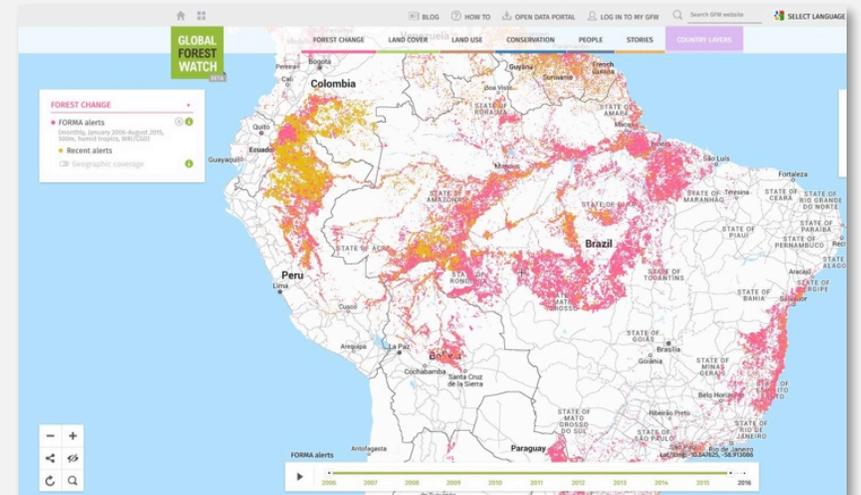
Remote Sensing Data Sources

Coarse Spatial Resolution (Optical)

- Greater than 250m
- Ex: MODIS, CBERS-2
- High temporal resolution useful for early warning and detection of forest clearing and degradation
- Example: FORMA
 - a monitoring system that issues monthly forest loss alerts for the humid tropics.
 - Generates alerts of likely forest clearing activity every 16 days at 500 m spatial resolution (Hammer et al. 2014)



NASA Worldview



FORMA Alerts from Global Forest Watch

Remote Sensing Data Sources

Medium Spatial Resolution (Optical)

- 10 m – 80 m spatial resolution
- Most common: Landsat (30 m) and more recently, Sentinel 2
- Benefits:
 - Historical archive (early 1980s)
 - Easily accessible and freely available
 - Global coverage
- Limitations: Areas of persistent cloud cover
- Example: Global Forest Watch (Hansen et al. 2013)



Top: Image of the French Riviera, credit: Copernicus data (2015)/ESA. Bottom: Landsat

Remote Sensing Data Sources

High Spatial Resolution (Optical)

- Better than 10 m spatial resolution
- Examples: Worldview 2 and 3
- Primarily used for accuracy assessment or hot spot assessment
- Benefits
 - Forest activity data can be monitored more accurately and with greater differentiation
- Limitations
 - Higher acquisition and processing costs
 - Spatial and temporal coverage may not be adequate

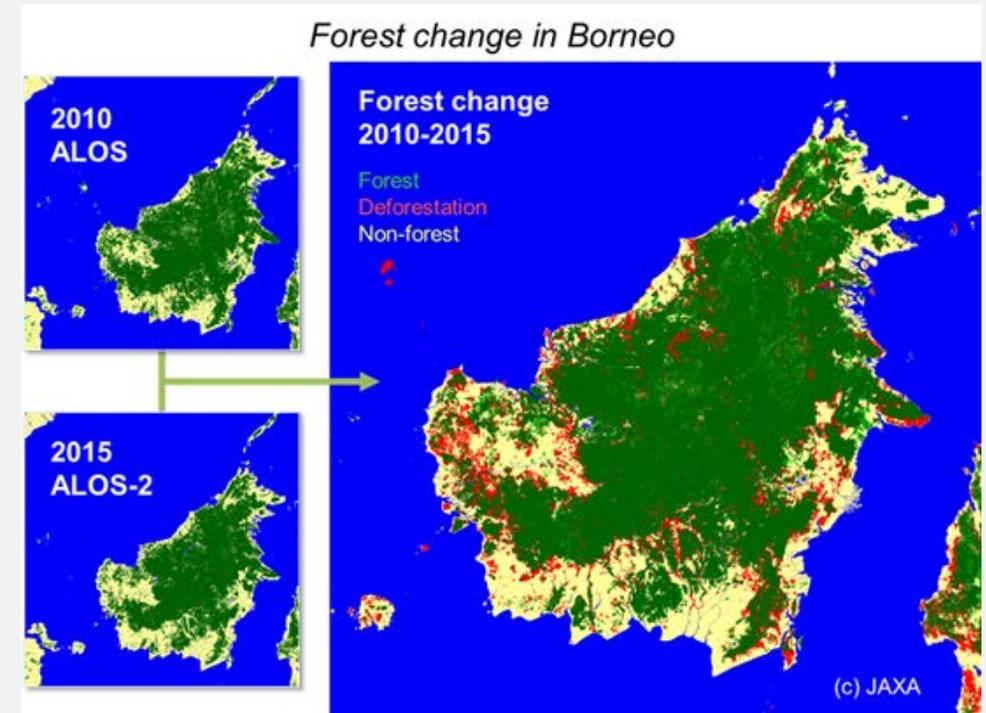


Nilo Forest Reserve, Tanzania. Credit: Digital Globe and Norsk Regnesentral

Remote Sensing Data Sources

Synthetic Aperture Radar

- Two types:
 - shorter wavelengths (C- and X-band SAR)
 - longer wavelengths (L-band SAR)
- Can detect forest/non-forest and changes
- Benefits:
 - Useful in areas of persistent cloud cover
 - Can provide information on forest structure; complementary to optical data
- Limitations:
 - Difficult to process
 - Not currently used operationally

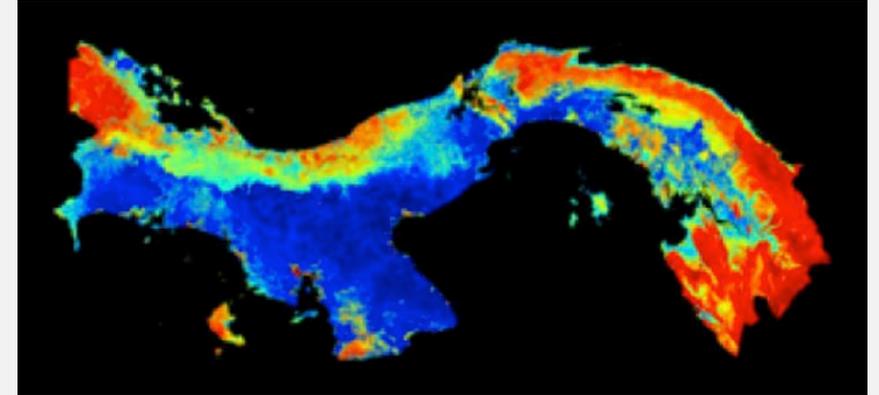


Forest change in Borneo (Masanobu et al. 2014)

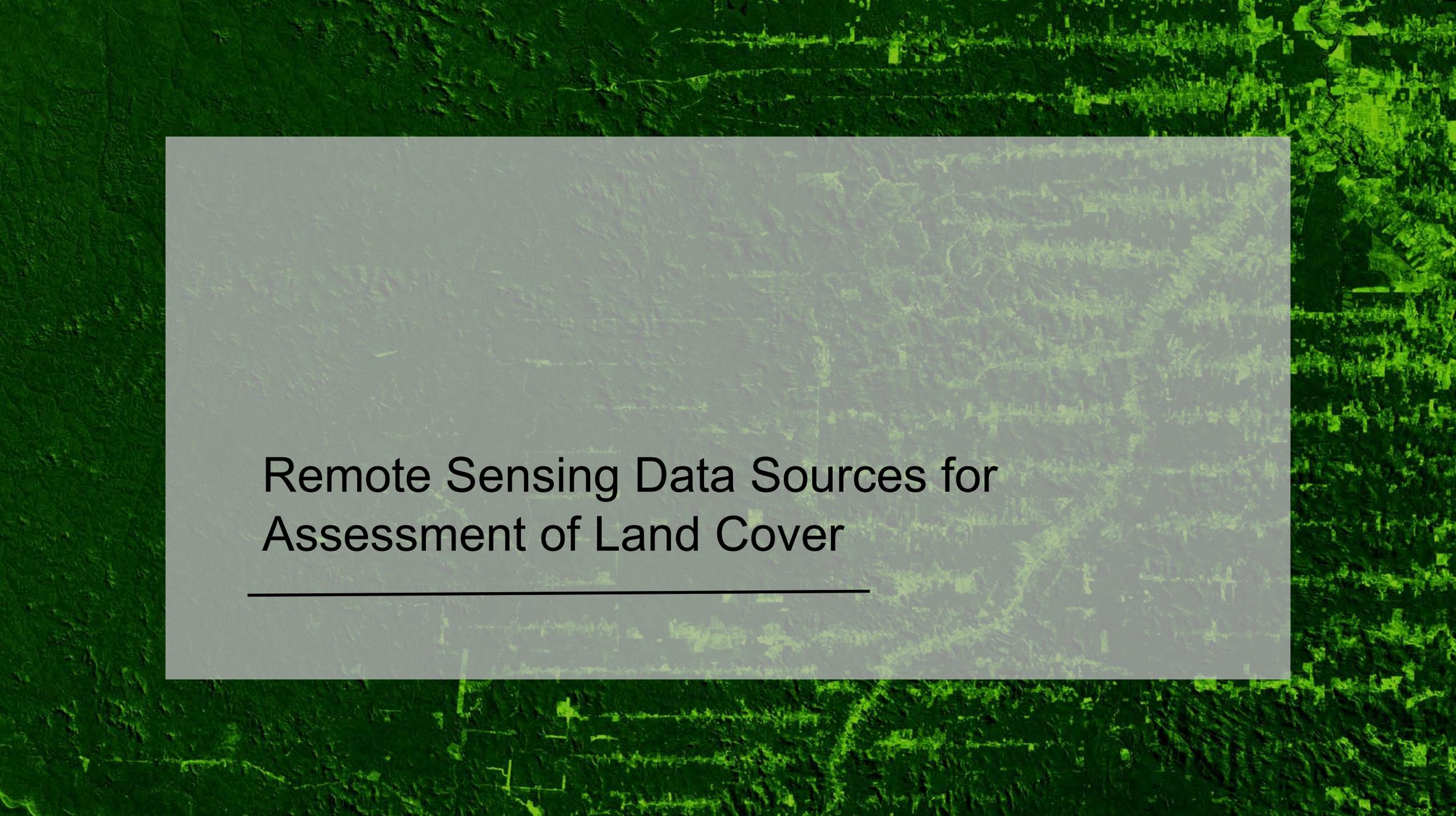
Remote Sensing Data Sources

LiDAR

- Provides information on forest structure (e.g. tree height, canopy volume) and biomass
- Currently acquired using aircraft platform – no operational LiDAR satellites
- Benefits
 - Provides detailed information of forest structure
 - Verification of biomass estimates, reduces need for ground sampling
- Limitations
 - Expensive to acquire & process



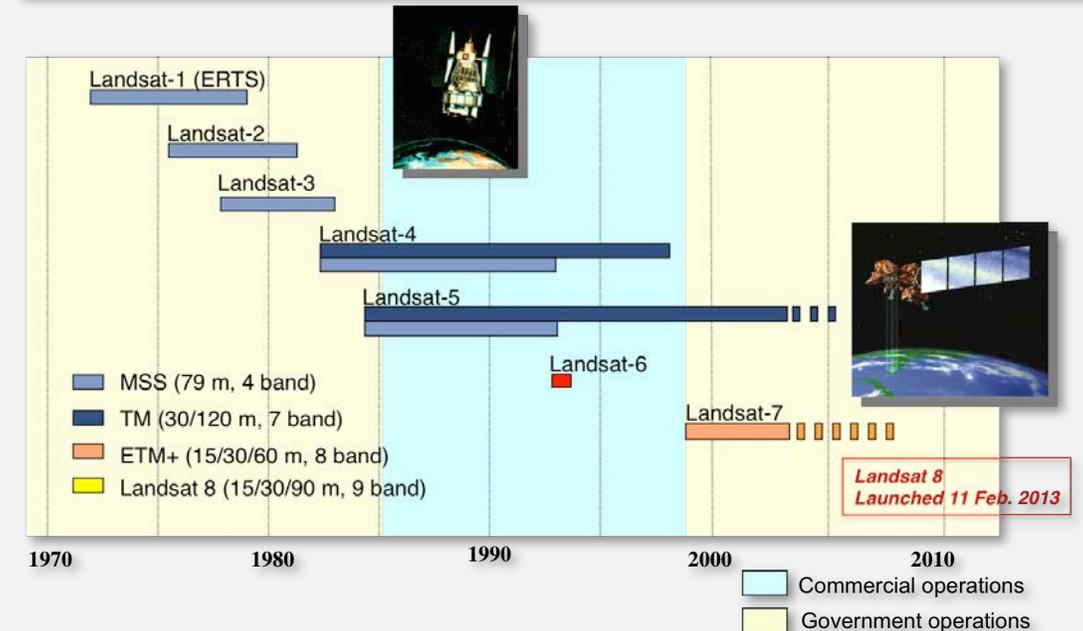
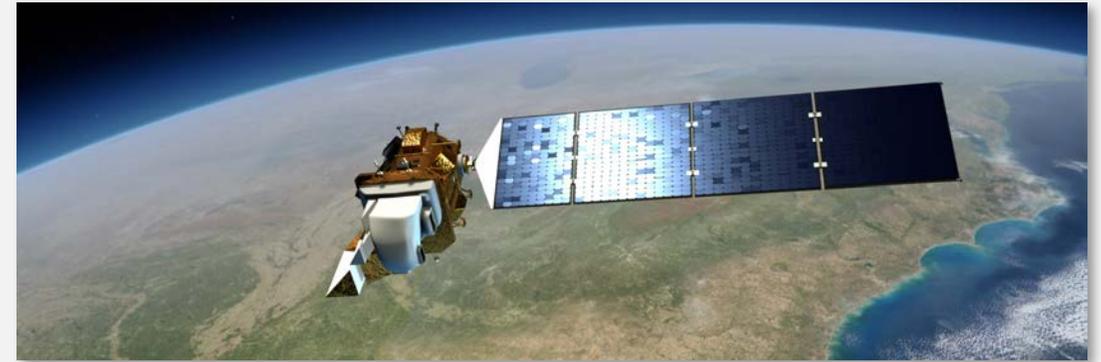
National carbon map of Panama by integrating field data with satellite imagery and LiDAR (Carnegie Institution, 2013). Credit: Carnegie Institution.

An aerial photograph of a forested landscape, showing a dense canopy of trees in various shades of green. A semi-transparent white rectangular box is overlaid on the center of the image, containing the title text. The background image shows a mix of dark green and lighter green areas, suggesting different types of vegetation or terrain.

Remote Sensing Data Sources for Assessment of Land Cover

Landsat

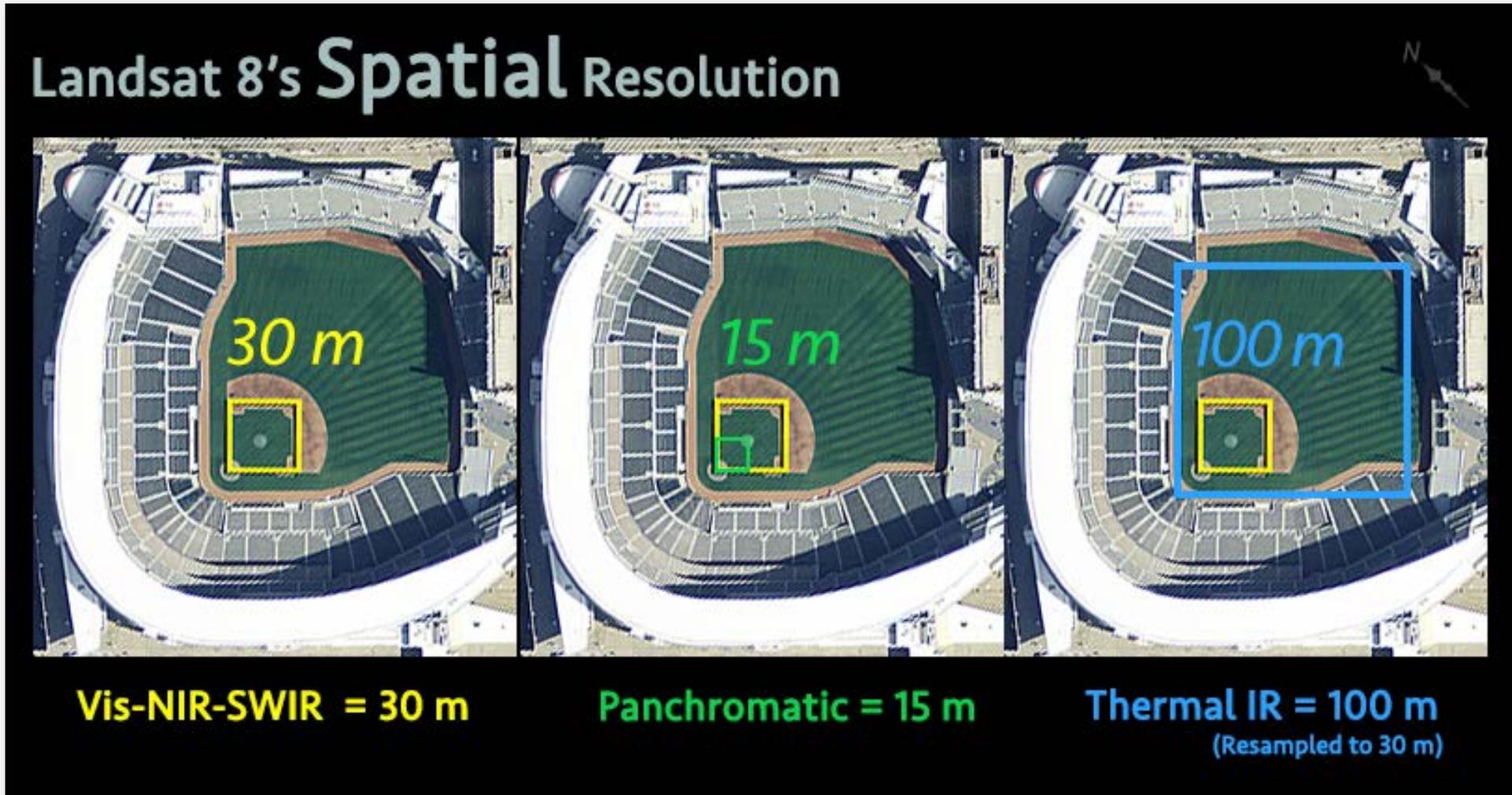
- First Landsat launched in 1972
- Landsat 8 launched in 2013
- NASA created and launched – USGS maintains data
- Passive sensor: obtains values of reflectance from Earth's surface
- 30 meter pixels, 15 meter panchromatic band
- Entire image of the Earth every 16 days



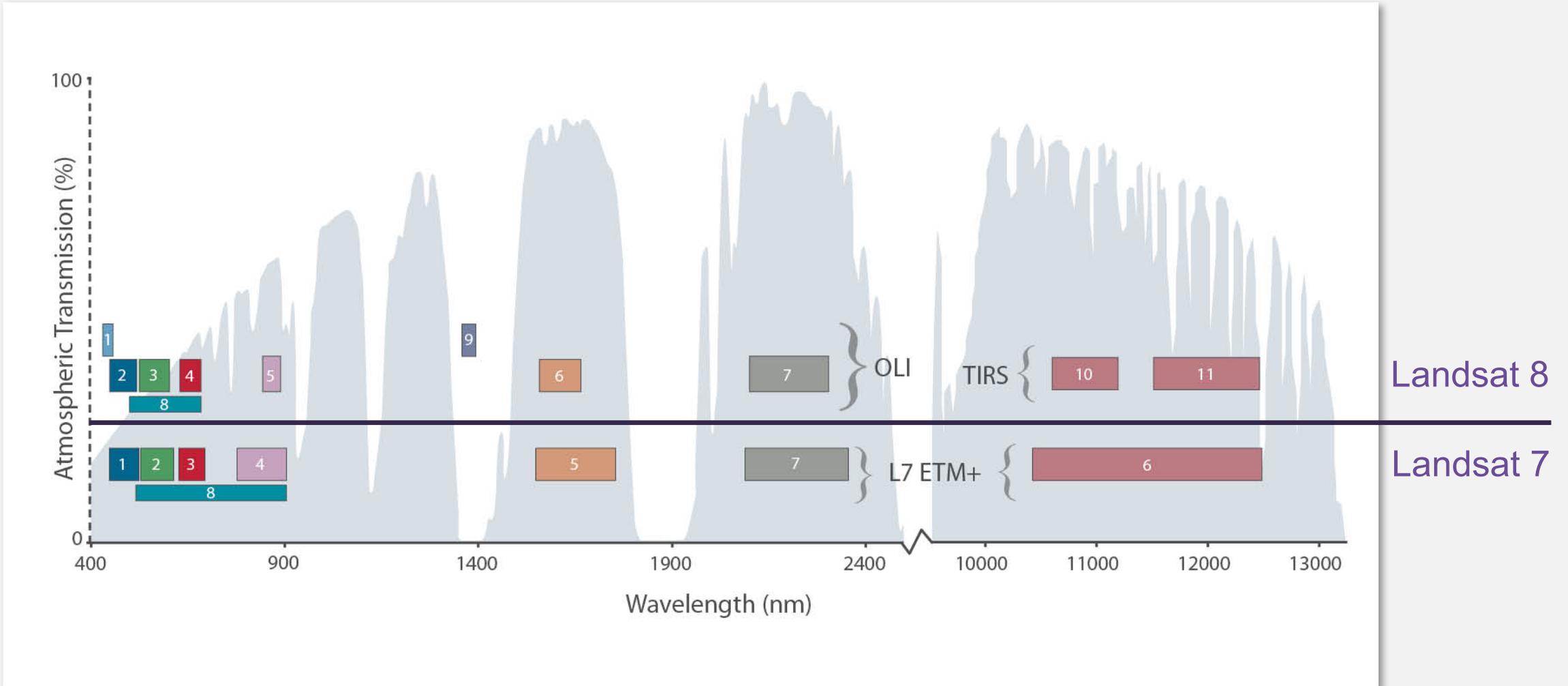
Landsat Bands

Landsat-7 ETM+ Bands (μm)			Landsat-8 OLI and <i>TIRS</i> Bands (μm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	<i>100 m TIR-1</i>	<i>10.60 - 11.19</i>	Band 10
			<i>100 m TIR-2</i>	<i>11.50 - 12.51</i>	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9

Landsat Spatial Resolution



Landsat Bands



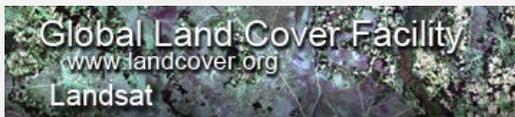
Where to Obtain Landsat Images



LandsatLook Viewer: <http://landsatlook.usgs.gov/>



GloVis Next: <http://glovis.usgs.gov/next/>



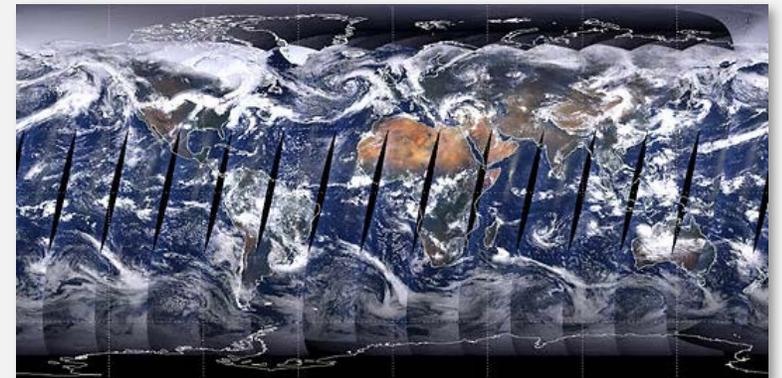
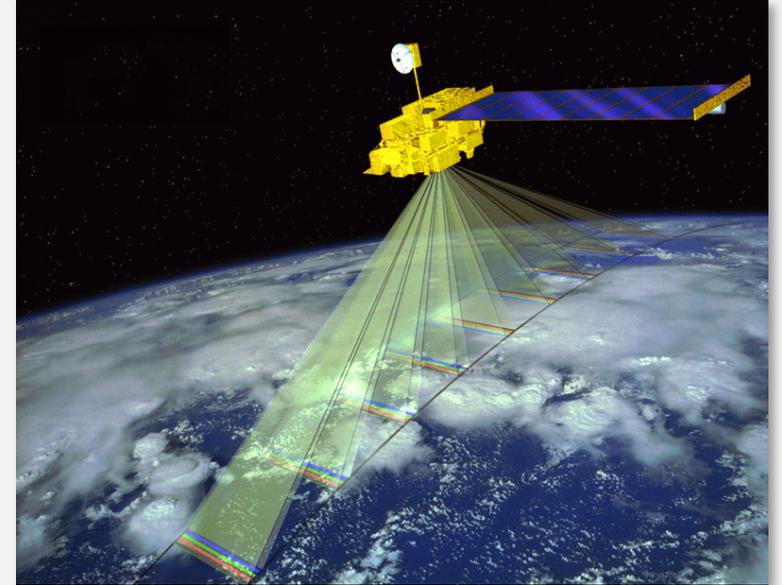
Global Land Cover Facility: <http://glcf.umd.edu/data/landsat/>



Earth Explorer: <http://earthexplorer.usgs.gov/>

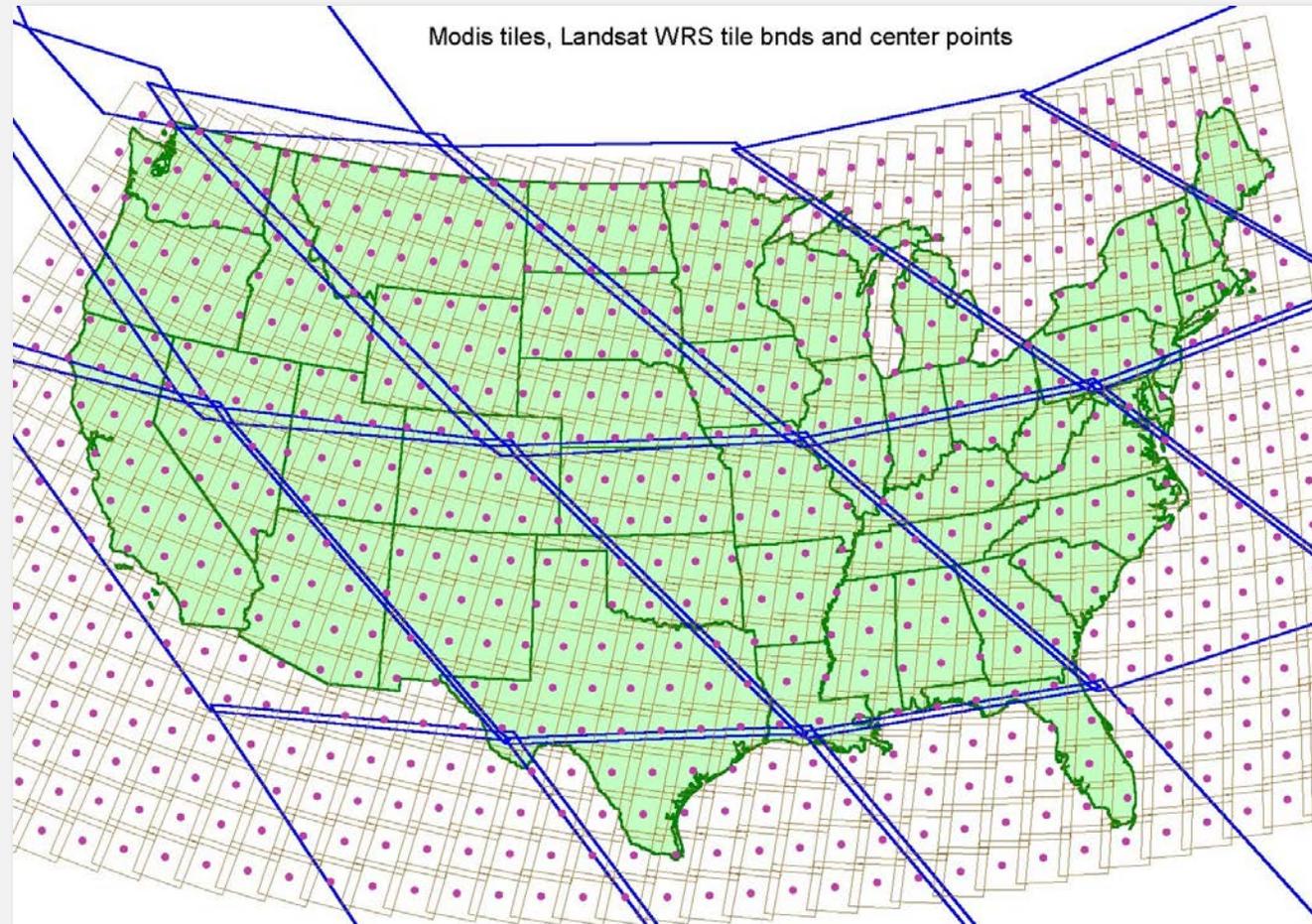
MODIS

- Spatial Resolution
 - 250 m, 500 m, 1 km
- Temporal Resolution
 - Daily, 8 day, 16 day, monthly, quarterly, yearly
 - 2000–present
- Data Format
 - Hierarchical data format – Earth Observing System Format (HDF–EO8)
- Spectral Coverage
 - 36 bands (major bands include red, blue, IR, NIR, MIR)
 - Bands 1-2: 250 m
 - Bands 3-7: 500 m
 - Bands 8-36: 1000 m



MODIS vs. Landsat Images

- Large swaths!



Where to Obtain MODIS Products



Land Process Distributed Active Archive (LPDAAC):

<http://lpdaac.usgs.gov/>



ECHO Reverb: <http://reverb.echo.nasa.gov>



Worldview: <https://earthdata.nasa.gov/labs/worldview>



Earthdata Search: <https://search.earthdata.nasa.gov/>



National Snow and Ice Data Center:

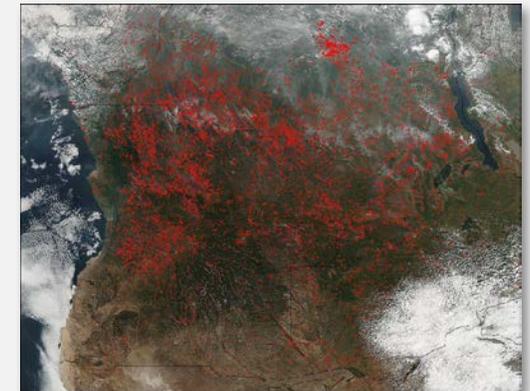
http://nsidc.org/data/modis/data_summaries#snow

Suomi NPP: VIIRS

- Visible Infrared Imaging Radiometer Suite (VIIRS): instrument aboard Suomi National Polar-orbiting Partnership (NPP)
- Collects visible and infrared imagery and radiometric measurements
- Launched 2012
 - NOAA took control of operations in 2013
- Daily temporal resolution
 - Global coverage
- Spatial resolution
 - 5 high resolution bands: 375 m
 - 16 moderate resolution bands: 750 m
 - 1 day/night band: can observe fires at night



VIIRS sensor on Suomi-NPP

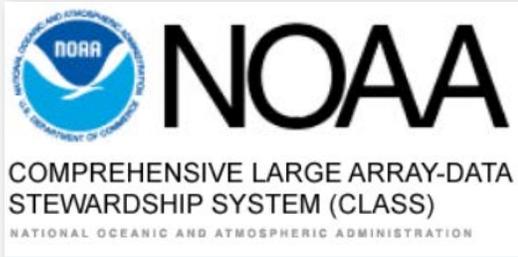


Fires in Central Africa acquired with VIIRS on Suomi-NPP on June 13, 2016 (Image credit: NASA, courtesy of Jeff Schmaltz)

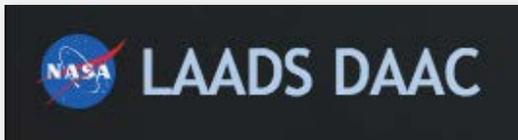
Where to Obtain VIIRS Land Products



Worldview (Fires, Land Surface Temperature and Snow Cover):
<http://earthdata.nasa.gov/labs/worldview>



NOAA Comprehensive Large Array-Data Stewardship System (CLASS):
<http://www.class.ngdc.noaa.gov/saa/products/welcome>



Level-1 and Atmosphere Archive & Distribution System Website:
<http://ladsweb.nascom.nasa.gov>

Sentinel-2

- Launched June 2015
 - Sentinel-2B in March 2017
- 2 Identical satellites
- 13 spectral bands
- Spatial Resolution: 20 m
- Temporal resolution: global coverage approximately every 5 days
- Applications:
 - Agriculture: yield prediction/plant growth
 - Forestry: land cover changes



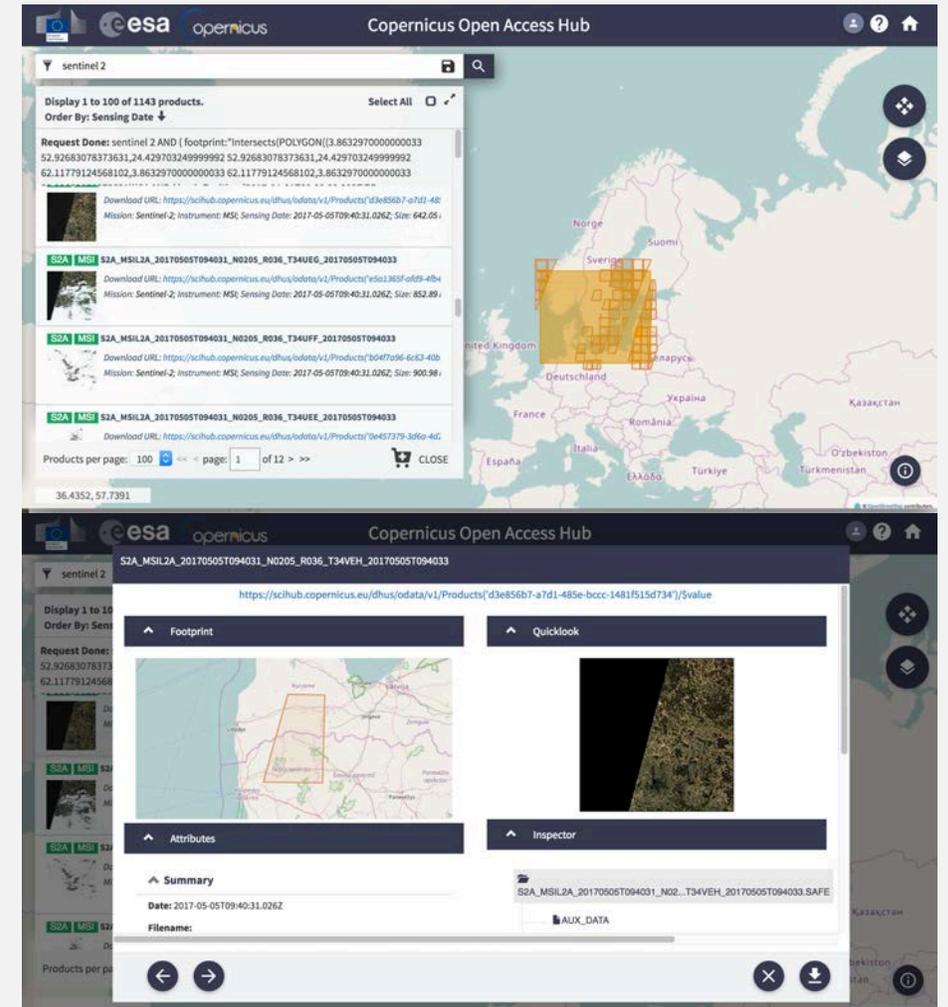
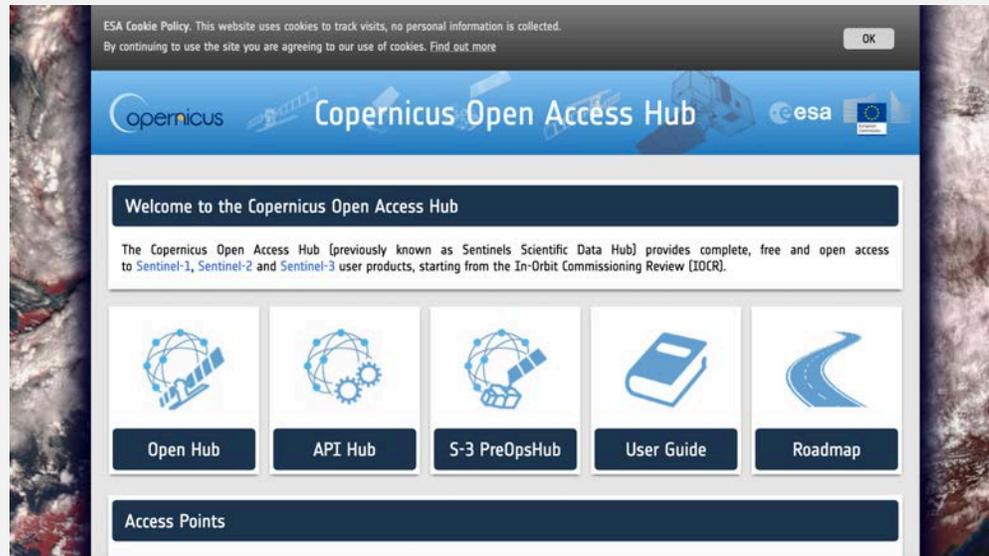
Sentinel-2 satellite (top); Sentinel-2 image of central-eastern Brazil from August 2016 (bottom). Photo Credits: ESA



Accessing Sentinel-2

Copernicus Open Access Hub:

<https://scihub.copernicus.eu/>



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ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

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Thank You

Next Session (tomorrow):

SDG Target 15.1